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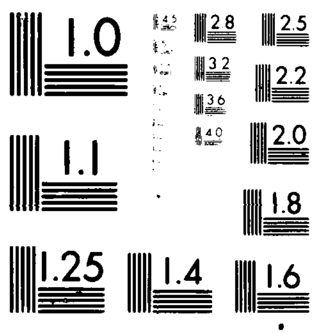

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MICROTERMINAL/MICROFICHE SYSTEM FOR COMPUTER-ASSISTED TESTING AND INTERACTIVE INSTRUCTION

By

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The development of a microterminal/microfiche system represents an effort to reduce the costs of computer-based instruction yet maintaining significant benefits associated with such instruction. The microterminal is a microprocessor-based, student input device designed to accommodate the computer-managed instructional functions related to student testing. The microterminal interfaced with an off-the-shelf microfiche reader also provides a low cost, low level form of computer-assisted instruction. Cost reduction goals in the design of the system were a function of focusing attention on response handling capabilities of the system and the utilization of more conventional information presentation media.

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MICROTERMINAL/MICROFICHE SYSTEM FOR COMPUTER-ASSISTED TESTING AND INTERACTIVE INSTRUCTION

I. INTRODUCTION

The 1970's was a period of exploration for computer-based instruction (CBI). By the end of the decade, the opportunities to be derived from the application of computers to instruction had become clearer and were being accepted routinely. The challenge for the future is to develop the opportunities that are in sight.

In the past, the hardware technology itself was the challenge. Concern properly was focused on the development of maximum hardware capabilities. This focus resulted in the creation of several first generation CBI systems. The better known of these first generation systems are of course PLATO and TICCIT. In the military context, other systems such as the Air Force's Advanced Instructional System (AIS) and the Navy's Memphis Computer-Managed Instruction (CMI) System were also developed. All of these systems were based on the existing mainframe, time-sharing hardware technology which existed at the time. All owe their existence to the large capital expenditures of Federal money necessary to explore any new high risk technological area. All of these systems demonstrated that CBI was possible and effective. What faces these systems and their evolution as well as the development of second generation systems, is the need to reduce the cost and uniqueness of CBI and thus make it an integral part of educational and training activities. This is now feasible because computer technology has evolved to a point of great diversity and greatly lowered cost.

Exploring the technological feasibility of new capabilities should no longer be a prime criterion. Rather, more focus and concern should be given to the economical and logistical problems of the user in being able to take advantage of the benefits of CBI. What this implies is development toward multiple levels of CBI application while maintaining the coherence of system level design and support. The Air Force has begun to explore such possibilities.

The development of the Air Force microterminal/microfiche system is an effort to use the new microprocessor technology to provide a lower cost data collection and instructional delivery capability which can be independent in operation yet can function in the broader context of a large CBI system. This paper presents the appropriate research accomplished and in progress by the Air Force Human Resources Laboratory, Logistics and Technical Training Division, Technical Training Branch. More extensive information on the development of the Air Force microterminal is available in Technical Report AFHRL-TR-78-50, Development of a Low-Cost, Stand-Alone Microterminal for Support of Testing and Instruction (1). Technical Report AFHRL-TR-80-17, Microterminal/Microfiche System for Computer-Based Instruction: Hardware and Software Development, details the interfacing of the Air Force microterminal with an off-the-shelf microfiche unit (2).

II. BACKGROUND

In 1973, the Air Force undertook a program, the Advanced Instructional System (AIS) to investigate the effectiveness of CBI and individualized instruction in making technical training more cost effective. It was expected that a CBI system, such as the AIS, would achieve cost effectiveness through significant reductions in the time for training Air Force personnel. The goal of the AIS was to maintain previous levels of training proficiency with a 25% reduction in overall training time. This goal was met and in some cases exceeded. To date, over 1,400 student years of training time have been saved.

The AIS was designed to be primarily a CMI system wherein the majority of instruction would be conveyed through off-line instructional materials (programmed texts, filmstrips, videotape, performance laboratories, etc.). In the context of CMI, computer-assisted instruction (CAI), wherein the student sits at a computer terminal to receive instruction, is seen as an assignable medium and one which would be used for specific instructional requirements.

III. INSTRUCTIONAL REQUIREMENTS AND MICROTERMINAL DESIGN

One important reason for an emphasis on CMI in the design of AIS is that CMI impacts a larger student population for a given investment of resources. Following the general philosophy of Mastery Learning, the computer management of off-line criterion referenced materials supports a large number of students through the use of a few computer management terminals. In the AIS, a daily student population of 1,200 students can be supported by approximately nine management terminals.

The management terminals in the AIS are expensive devices consisting of an optical mark reader, a printer, and a PDP 11/05 minicomputer. Students interact with the management terminal via mark sense forms. These forms cost an average of $.03 each. With a criterion reference test given at approximately every hour to every hour and a half of instruction, the volume of forms used is quite large. The cost of forms plus the cost of management terminals represent a significant cost element in the AIS system. In addition to cost, problems of reliability and maintainability are associated with the mechanical aspects of optical mark reader technology. As a consequence of the mentioned factors a prime design consideration for the microterminal was to see if a simple hardware solution could be realized for the input of individual test data. This would enable an initial capital investment in hardware to replace the recurring costs of computer form usage.

Since the majority of knowledge testing in the AIS is based on the use of objective test items, it was clear that the design of the microterminal's input capabilities could be realistically limited to a configuration sufficient to handle student input for these types of test items. But, since testing is only one instructional function in a CBI system, the question arose as to whether the design of a low-cost student input terminal could be beneficial to the instructional delivery aspects of the system.

An important form of instructional delivery is CAI. As mentioned previously, CAI can be considered as another presentation medium under the control of CMI. Compared to other media for delivering criterion referenced instruction, CAI can be quite costly. Much of the cost inherent in CAI is a function of the cost of appropriate terminals. Unlike a CMI terminal which can support a large number of students, CAI terminals are,by the nature of the instructional activity involved, limited in their support capacity. Significant increases in the use of CAI dramatically increase the number of computer terminals required. This is a significant concern when the costs of typical CAI terminals have been in the range of several thousand dollars. CAI as an instructional concept is important though, because it offers interactivity between the student and the instructional material. Such interactivity is typically absent from off-line instruction in CMI.

Depending on the type of functions supported by the CAI terminal, its cost can range from approximately $1,500 to more than $10,000. Originally CAI systems were adaptations of computer hardware and software designed for business or scientific "number crunching" activities. Such systems were usually designed as general systems so as to appeal to a wide range of users or applications. When CAI systems were developed strictly for instructional purposes (such as PLATO IV), their initial approach was also of a general purpose nature - a single architecture and terminal hardware to satisfy a wide range of users.

A different approach and one which is being investigated in the context of the AIS gives consideration to the fact that a hierarchy of instructional requirements exists and that there should be a matching hierarchy of terminal hardware. In the realm of CAI, an often heard complaint is that the CAI application has degenerated to a page-turning activity. This may not be simply due to the lack of instructional design skill on the part of a user, but because the instructional aspects require only the simple linear presentation of verbal information, and the only available computer capability exceeds the requirements of the instructional situation. It may be argued that in such situations computer capability is not required. However, as will be shown, simple computer applications may have significant instructional effects.

In looking at CAI, a clear distinction should be drawn between the presentation of instructional information and the control of the interaction of student with the instructional material. In the CAI literature, a better case can be made for the instructional effectiveness of the interactive interchange between student and instruction than for any unique computer presentation of instructional information. If the instructional requirements are such that simple verbal or non-dynamic graphical information is sufficient to present the instructional message, it can be more cost effective to continue such presentations in more conventional formats or delivery mediums, if they could be supplemented with a mechanism to allow the student to interact with the material.

The typical manner in which students are made to interact with instruction is through the question and answer process. Again the typical CAI approach to such interaction has been to provide sophisticated levels of processing to handle not only the predominant multiple-choice or objective type test item but also to allow constructed responses anywhere from one word to a whole paragraph in length. However, the usefulness and effectiveness of multiple-choice questions is well established for a wide range of instructional activities and materials. The second factor considered in the design of the microterminal was to provide a simple means by which students could interact with off-line presentations of instructional materials through the process of responding to objective type test items.

IV. THE MICROTERMINAL CONFIGURATION

The Air Force microterminal went through several iterations of design before the final prototype configuration was determined. Technical Report AFHRL-TR-76-66, Microcomputer Controlled, Interactive Testing Terminal Development, details this early development (3). To summarize the design and development of the final prototype which is now being utilized the following determinations were made:

1. The microterminal should be independent of the central site CMI computer.

2. To avoid expensive communication costs, the microterminal should interface with the central computer through the existing management terminal configuration.

3. To avoid expensive presentation hardware (i.e. CRTs, Plasma Panels, etc.) presentation of test items or instructional materials is assumed to be through conventional media.

4. Responding will be limited to multiple-choice or objective type questions or test items with provisions for various levels of feedback.

The final prototype configuration of the microterminal developed into a device measuring 11" x 9" x 5". The display features are four alphanumeric characters and nine light emitting diodes (LEDs). The four alphanumeric characters can indicate test item or instructional frame number, indicate the student's response choice, and give simple feedback messages such as "yes" or "no." Five of the nine LEDs are used to indicate the status of directive messages. These messages as used in the initial evaluation of the microterminal to support end-of-instruction testing are as follows:

1. Enter Social Security Number

2. Enter Booklet Number

3. Test in Progress

4. All Questions Answered

5. Press ENTER or CLEAR

In addition to the five LED indicators described above, there are also four colored LEDs which can be used to direct the student to color coded sections of instructional materials. The keyboard of the microterminal is a 16 pad keyboard which allows the entry of answer choices A-E and numerics 0-9, and has six special function keys. The microterminal also features a removable memory module which can contain one or more read and write random access memory (RAM) chips supported by a small rechargeable nickle-cadmium battery. The memory module stores a student's responses and permits communication with the central CMI computer system.

V. THE INSTRUCTIONAL APPLICATION OF THE MICROTERMINAL

The initial application of the Air Force microterminal has been for the support of end-of-instruction testing in technical training courses under the AIS. These tests are referred to as Block Tests, which are multiple-choice type tests administered typically after one to two weeks of instruction. These Block Tests are major controlled tests used for certifying the achievement of the students. Normal AIS testing had students taking these tests using test booklets and marking their answers on computer readable test forms. The microterminal was introduced such that students now responded to the test questions using the microterminal rather than a test form.

The scenario for the student using the microterminal for taking a Block Test would be as follows: The student is issued a test booklet and a blank memory module. Going to a test station, the student inserts the memory module into the microterminal. The LED beside the message "Enter SSN" lights up. After the student enters the Social Security Number, the last four entered digits appear in the alphanumeric display. When nine digits have been entered, the LED beside the message "Press ENTER or CLEAR" lights up, and the student satisfied with the entry presses the key marked "ENT." The LED beside the message "Enter Booklet Number" lights, and the student enters the booklet number on the front of the test booklet and presses the key "ENT." The message "Test in Progress" is now illuminated and "1=?" appears on the alphanumeric display. The student chooses a response to the first test question and presses the appropriate answer key. The answer is then displayed such as "1=A."

The student continues answering test items. If students come to a test item which they cannot immediately answer, they can skip it by pressing the key marked "STEP," which allows them to proceed to the next item. The

microterminal automatically keeps track of all skipped test items. When the student has responded to the last test item, the microterminal takes the student back to the first test item answer display. Since the student had skipped some test items, the message "All Questions Answered" is not illuminated. Using the review key marked "RVW," the student can go back to each skipped item to answer it. Also, at any time the student can use the key marked "#" to access any previously answered item to change an answer. When all questions are answered, the message "All Questions Answered" is illuminated; however, the student need not answer all questions before being able to have the test graded.

After finishing, the student removes the memory module and takes it over to a management terminal and inserts it into another microterminal, presses an ENTER key, and waits for the management terminal to print the test results and next instructional assignment. If the central site computer system is down, the instructor can grade the student's test by inserting the memory module in an instructor version of the microterminal. The instructor can get a total test grade and retrieve the answers the student made to each test item.

VI. MICROTERMINAL AND MICROFICHE COMBINATION

As previously stated, the cost of the microterminal was kept low by minimizing its electronic display capabilities. The initial use of the microterminal was with the support of printed criterion test materials; however, printed materials, though useful in some situations, are not an optimum medium for interactive instruction. The shortcoming stems not so much from the presentation format of printed materials as it does from poor control over sequence of information or feedback access. Regardless of whether the medium is electronic or film-based, the appropriate medium for interactive instruction is one which permits "random" or non-linear access to information.

In keeping with the low-cost design considerations for the microterminal, a low-cost presentation medium was required; one which, in addition to low-cost, would fit the general design philosophy of presenting instructional information off-line and yet capture the facility of computer, algorithmic control over instructional sequence and student responding.

The physical format of microfiche is especially suited to accessing information in a non-linear sequence. Any combination of row and column locations can be used in an instructional sequence. Additionally, the format of the fiche itself can be arranged to physically represent a particular sequence strategy. For example, center columns could be devoted to main instructional topics while right-hand columns could represent additional examples and left-hand columns could represent corrective feedback or

remedial information. As can be seen, the microfiche format is supportive of interactive instruction and its non-linear sequences. However, a major design decision for the development of a microterminal/microfiche system was how to control access to information.

The goal of having a low-cost terminal and delivery capability would be negated if the off-line microfiche display device was expensive. Automated random-access microfiche readers were considered but were discarded on the basis of cost and belief that automated access was not necessary within the limits of information contained on a single fiche. The difference in cost between an automated microfiche reader and a quality manual reader is dramatic ($2,200 vs. $150). Manual location of fiche information was not seen as a hindrance if the learner is provided with clear direction as to location and if the instructional process cannot continue unless the learner is at the right location on the fiche as assigned.

The microterminal exercises control over fiche location via an interface and position detection capability added to the manual microfiche reader. In accordance with an instructional or test sequence strategy, the microterminal conveys row and column information for the student to locate the next test item or lesson information on the fiche. Through the interface, the microterminal "knows" the location of the fiche carrier on the reader. Only when the learner is at the right location will the microterminal turn on the reader's light revealing the appropriate test item or lesson information.

In addition to interfacing a microfiche reader to the microterminal, additional capabilities were added to enable the microterminal to be a networked unit in a system which included a general purpose "personal" computer. This combination provides a mini-CBI system wherein the personal or desk-top computer with its general processing capabilities and magnetic disc storage can maintain test records, test and lesson control algorithms, etc. Information stored in the microcomputer defines how a learner will interact with a microfiche based test or lesson. Specific control information stored in the microcomputer is downloaded to a memory module which the learner then inserts into his/her microterminal. Likewise, when a test or lesson is completed, the learner transfers response data back to the central microcomputer via the memory module.

VII. USE OF THE MICROTERMINAL/MICROFICHE SYSTEM

To date, the primary use of the microterminal/microfiche system has been for the support of criterion testing. In terms of this function, its acceptance by both students and instructors has been shown. As a low-cost terminal potentially replacing the use of computer forms in the support of CMI functions in a large CBI system, the microterminal has proven itself reliable, flexible, and cost-effective. The use of microfiche in conjunction with the microterminal will provide a very low-cost display medium for providing random accessed test items for implementing various computer-assisted testing strategies.

An example of the latter use has been a demonstration project in which an APPLE II microterminal is used to assign a "test item path" for a student to go through a test item pool contained on microfiche. The control algorithm is downloaded from the microcomputer to the memory module of the microterminal. The student, after completing the test, takes the module back to the microcomputer which processes the test item response data. A test report is then provided to the instructor and student. If the test was failed, the microcomputer program, upon later retesting, would assign an alternate test item path, but only for those criterion objectives which were failed. Additionally, for test critique purposes, the microcomputer can load the student's module with a control algorithm that will guide the student through a remedial fiche on test item materials missed.

VIII. CONCLUSION

With the continuing advent of sophisticated computer and related technologies such as video-disc, a question arises as to the future value of such a simple technology as the microterminal/microfiche system. The primary usefulness of this technology is that it is low cost and, most importantly, permits the ready conversion of existing instructional content, either printed or film format, to an acceptable level of interactive instruction. Too often with new technology the emphasis is on pushing back the technological frontier and thus neglecting the fundamental concerns of production, support, and use of the technology. There is no doubt that in the future less-costly and more powerful capabilities will be developed. But, in the meantime, there are definite needs for "appropriate" transitional technologies. The microterminal/microfiche system was designed to be such a transitional technology.

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